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J. A. KRUG, SECRETARY

BUREAU OF MINES
R. R. SAYERS, DIRECTOR

INFORMATION CIRCULAR

USE OF ROCK DUST AND WATER UNDER THE FEDERAL MINE SAFETY CODE IN LIMITING COAL-DUST EXPLOSIONS

BY

J. J. FORBES AND C. W. OWINGS

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USE OF ROCK DUST AND WATER UNDER THE FEDERAL MINE SAFETY CODE IN LIMITING COAL-DUST EXPLOSIONS[1]

By J. J. Forbes[2] and C. W. Owings[3]

INTRODUCTION

The recent coal-dust explosions in Illinois and Indiana have again brought forcibly to the attention of mining men the fact that mines which liberate little or no methane can have widespread explosions, if dry and dusty conditions exist and if adequate measures are not taken to control the dust hazard by rock dusting or use of water.

Even though rock dust has been used more or less extensively for more than 20 years as a means of limiting or preventing coal-mine explosions, many mine operators have requested information on rock dusting and means of allaying coal dust at its source. The purpose of this circular is to summarize available information on these two methods.

COAL MINES TO BE ROCK-DUSTED

1. All nonanthracite coal mines must be rock-dusted, except those mines or locations in a mine that are too wet or too high in incombustible content to propagate an explosion.

2. Coal dust that contains 20 percent or more moisture may prevent ignition or propagation of an explosion. Such dust can be molded in the hands, and under such condition the roadway would be considered muddy. Mine dust that is only damp is not wet enough to prevent propagation of an explosion. Beads of water standing on accumulations of dust are not indications that the dust is wet. Only those mines or locations in a mine in which the coal dust can be molded in the hand need not be rock-dusted.

ROCK DUSTING REQUIRED BY FEDERAL MINE SAFETY CODE

3. The Federal Mine Safety Code requirements for rock dusting are:

Article VI, Section 2a.

All mines, except those mines or those locations in a mine which are too wet or too high in incombustible content to

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propagate an explosion, shall be rock-dusted to within 80 feet of the faces of rooms and entries; however, if the mine or any part of it is wet but becomes dry, the mine or portion of the mine so affected shall be rock-dusted as soon as it becomes dry.

Section 2b.

In mines partially rock-dusted or in mines that are required to start rock dusting, haulageways and parallel entries connected thereto by open crosscuts shall be rock-dusted. Back entries shall be rock-dusted for at least 1,000 feet outby the junction with the first active entry. Inby this junction, the rooms, entries, and crosscuts shall be rock-dusted by generalized rock-dusting as provided for in section 2a.

Section 2c.

Where rock dust is applied, it shall be distributed upon the top, floor, and sides of all open places and maintained in such quantity that the incombustible content of the mine dust will not be less than 65 percent. In trackless entries and air courses, protection in lieu of generalized rock dusting may be had by using bags filled with rock dust, if they are placed at regular intervals and staggered as described in Bureau of Mines Report of Investigations 3411.

Section 2d.

When methane is present in any ventilating current, the 65 percent of incombustible matter shall be increased 1 percent for each 0.1 percent methane.

4. The area within 80 feet of the face in rooms and entries is the greatest distance that may remain free of rock-dust application. This means that, whenever any face is driven so that it is 80 feet from the rock-dust application, additional rock dust may be applied. Preferably the rock dust should be maintained within two or three cuts of the face.

5. Dust in mines or sections of mines frequently becomes wet during summer months but dries during cold weather. Whenever the dust is no longer wet enough to prevent propagation of an explosion, rock dust should be applied.

6. If a mine has not been rock-dusted, all the haulage roads and parallel entries connected thereto by open crosscuts should be rock-dusted. The back entries or airways not used for haulage or travel frequently have numerous falls in them, and rock dusting is difficult. For that reason, the Code requires rock-dusting of back entries for at least 1,000 feet outby the first active entry. This will prevent an explosion initiated inby from the propagating along back entries. All open areas inby this junction, including back entries in the first active set of entries, should be rock-dusted.

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7. The incombustible content of the dust in rock-dusted areas should be at least 65 percent, and if methane is found in any ventilating current, the 65 percent incombustible content should be increased 1 percent for each 0.1 percent methane present. The highest methane content in any ventilating current governs the additional incombustible material required for the entire mine and not for that particular split of air.

STATE LAWS REGARDING USE OF WATER AND ROCK DUST

8. Laws have been enacted in practically every principal coal-producing State for controlling coal-dust-explosion hazards. Missouri has no provision for allaying the dust or for rock dusting. Utah requires that rock dusting be done with regularity and frequency where surfaces are required to be rock-dusted.

9. Arkansas requires the use of water on the cutter bars of all mining machines and on all jackhammer drills in either coal or rock. No provision or requirement for rock dusting is made in this law. Iowa requires that any dry and dusty roadways be sprinkled at least once a week and oftener as conditions may require, but no mention is made of rock dusting. Practically the same requirements are contained in the Kansas mining law, except that accumulated dust in air courses, entries, rooms, and crosscuts must be sprinkled or removed from the mine.

10. Laws of the majority of the coal-mining States provide for applying water or rock dust or both where an explosion hazard may exist. This provision is part of the mining laws in Alabama, Colorado, Illinois, Indiana, Kentucky, Montana, New Mexico (requires rock dusting unless all coal dust is in a muddy condition), Ohio, Oklahoma, Pennsylvania, Virginia, Washington, West Virginia, and Wyoming.

11. Maryland law provides that dry dust that may tend to cause an explosion must be kept well-watered or other efficient, approved means shall be used. This may be interpreted to refer to rock dusting. Tennessee requires that, in dry and dusty mines, all dangerous accumulations of dust shall be removed or maintained in a safe and moist condition by sprinkling or spraying with water or other non-inflammable liquid.

EXPLOSIBILITY OF COAL DUST

12. The Bureau of Mines has determined by tests that coal dust, except anthracite dust, is explosive upon encountering a source of ignition when mixed in a cloud in air, and the finer the dust the more explosive it is. The fine coal dust that floats in the air current settles on the crossbars, timbers, and the ribs and is more explosive than coarse road dust. Even low-volatile coal dust with 14 percent or less volatile matter in the coal will explode when mixed in a cloud in air and in contact with a source of ignition. Ignition of coal dust from low-volatile coal may be difficult, but experience has shown that, once started, an explosion may be equally as violent as in high-volatile coal mines.

13. The addition of fine rock dust will prevent the coal dust from igniting if both dusts are raised into the air together. The explosibility of the coal dust is indicated by the quantity of incombustible dust that may be added to prevent the flame of an explosion from being spread by the coal dust.

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SPECIFICATIONS FOR ROCK DUST

14. The American Engineering Standards Committee, on which several members of the Bureau of Mines staff served, recommended the kind and size of dust to be used for rock dusting as follows:

(a) The kind of dust to be used shall be as specified by the U. S. Bureau of Mines, and subject to the approval of the State Mine Inspection Service. It shall not contain more than 5% of combustible matter, nor more than 25% of quartz or free silica particles, nor absorb moisture from the air to such an extent as to cake and destroy its effectiveness as a dry dust. It may be made from limestone, dolomite, gypsum, anhydrite, shale, talc, adobe, or other inert material which meets the foregoing specifications. The lighter colored dusts are to be preferred.

(b) The dust to be used shall be pulverized so that 100% will pass through a sieve having 20 meshes per linear inch, and 50% or more will pass through a sieve having 200 meshes per linear inch (40,000 perforations per square inch).

(c) In all places where rock dust is distributed, enough shall be used so that the percentage of incombustible material in the samples of dust collected in the places shall be maintained at least 55%. Along room entries or gangways where methane gas is found in the ventilating current, the amount of incombustible material above specified shall be raised 10% for each 1% of gas.

15. The requirement that not more than 5 percent combustible material be contained in dust is liberal. A number of dusts contain 2 percent or less combustible material, and these dusts should be used in preference to those having high combustible content.

16. The limit of 25 percent free silica was made to allow certain shales to be used for rock dust. In the 20 years since these specifications were written, it has become evident that dusts generally used contain 2 percent or less free silica or quartz; therefore, where possible, the dust should contain not more than 5 percent free silica. Dusts in heavy concentrations in air, especially those containing silica, may be harmful to those who regularly inhale the dust; therefore, men applying rock dust should be protected by wearing approved respirators.

17. The dust should not absorb moisture from the air to such an extent as to cake and destroy its effectiveness as a dry dust. Tests made by the Bureau of Mines have indicated that pure, high-calcium limestone dust cakes less than other rock dusts. Generally, caking increases as the impurities in these dusts increase. Gypsum and shales cake excessively; therefore, they are less desirable than limestone or dolomite dust. Rock dust with a light color is preferable.

18. Although specifications call for 50 percent or more dust to pass through a 200-mesh screen, Bureau of Mines tests have shown that dust 70 percent of which

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passes through 200-mesh gives the best results in stopping explosions. If less than 50 percent of the dust passes through a 200-mesh screen, proportionately more dust is required.

19. The specification that dust containing 55 percent incombustible matter be maintained on surfaces in the mine is too low for bituminous-coal mines. The requirement in the Federal Mine Safety Code that at least 65 percent incombustible matter be maintained in the mine dusts gives a greater factor of safety. The additional requirement that 1 percent rock dust be added to the 65 percent for each 0.1 percent methane in any air current is necessary to overcome the greater explosibility of the dust when methane is in the ventilating current.

HOW TO ROCK-DUST

20. To be effective, accumulations of combustible dust should be removed before rock dust is applied.

21. The mining method should provide for keeping the face clean of loose coal and dust as the coal is loaded out. This is generally done in hand-loading; but in mining with mobile loaders, much loose coal may be left on the floor. Two of the methods of accomplishing proper clean-up of coal and dust at working faces are known to be relatively effective. In some mines, when cars are being changed, the loose coal that has not been loaded or cannot be loaded by the machine is shoveled into the loading machine by the operator and his helper. In this way, the floors are kept clean. The second method consists of having the loading-machine and locomotive crews join in cleaning up loose coal and shoveling it either into the car or onto the loading machine as the last car is loaded. Other procedures undoubtedly are equally efficient.

22. Rock dust may be applied with a machine or by hand. There are two types of machines, classified according to pressure, that is, low-pressure and high-pressure machines. The low-pressure machine is used for applying the dust to the surfaces of an entry by pulling the dusting machine along a track or transporting the dusting machine in a crawler-type, self-propelled car. These machines have either a fixed nozzle or have a short hose that can be directed toward the ribs and roof by a workman as the rock-dusting machine is hauled along the entry or room.

23. A portable rock-dusting machine mounted on skids is also available. It can be placed on a conveyor and used to rock-dust conveyor places; moreover, it can be placed in a mine car or on a truck when rock-dusting rooms and entries where crab-reel locomotives are used to gather cars. The portable machine may be placed in self-propelled cars when trackless entries are to be rock-dusted.

24. The high-pressure rock-dusting machine, in addition to being used to rock dust track entries and rooms, may also be employed to rock-dust trackless entries and rooms by forcing a stream of rock dust through hose. In some mines the hose is taken through a hole in a stopping.

MACHINE DUSTING

25. Rock dust applied by machine requires either a two- or three-man crew. The large-capacity rock-dusting machine may require only two men, as the rock

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dust may be placed in the hopper and a long stretch of entry may be dusted without stopping. With the low-capacity machine, it is generally found more economical to have three men. If a machine has a fixed-discharge nozzle, one or two men may be employed to place rock dust in the hopper continuously. Under these conditions, a car containing rock dust should be placed between the locomotive and the rock-dusting machine. If the machine requires one man to direct the nozzle, one man can replenish the supply of rock dust in the hopper. With a high-pressure machine, two men may be used, as one man can place rock dust in the hopper while the second man is directing the stream of dust from the end of the hose onto the surfaces to be dusted.

26. Wherever possible, the rock-dusting machine should proceed against the air current so that the dust will be carried away from the rock-dusting crew. This is not always possible, particularly if the machine is used for dusting in rooms and in parallel entries. As rock-dusting machines generally have to be pushed as well as pulled, a rigid coupling should be provided if feasible.

27. In the average entry, which is approximately 6 by 12 feet in cross section, about 4 pounds of dust per linear foot of entry should be applied. When passing crosscuts, care should be taken to rock-dust them adequately. If a fixed nozzle machine is used, the rate of progress should be retarded when crosscuts or wide places in an entry is passed.

28. Back entries not previously dusted should be rock-dusted for at least 1,000 feet outby the first active entry. One company has used brooms to clean back entries before dusting, but this is seldom possible. If it is not practicable to clean up excess dust, a heavier application of rock dust is required. If excessive dust has accumulated in back entries, it is desirable to have at least 1/2 inch of rock dust on top of such accumulations on the floor.

29. In mines using self-propelled cars, it may be possible to place a portable rock-dusting machine in the crawler-type car and so rock-dust the back entries from which track has been removed.

30. Track laid in back entries should not be removed until rock dust has been applied, if machines are employed for rock dusting. Application of dust in such locations should be about 6 pounds or more per linear foot of entry, as this probably will make it unnecessary to redust these back entries. Samples collected in such entries in some mines after a number of years have indicated that the rock dust was still present in sufficient quantity that redusting was not necessary. Where the size of rock dust is 70 percent or more through 200-mesh, the dust is finer than the coal dust that generally finds its way into the back entries, and where machine dusting is done near the working faces, the fine rock dust is carried into the back entries, thereby helping to maintain it satisfactorily.

31. In hand loading, or in mechanical loading where only one or two shifts are worked a day, rock dust can usually be maintained within 80 feet or less of the face without difficulty. In triple-shift operations, the problem of maintaining rock dust close to the face becomes more difficult where machines are used to apply the dust. One company has solved the problem by applying rock dust by hand to within 25 feet of the faces. This is done during the shift

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with no appreciable annoyance to the remainder of the crew. Generally the machineman or driller applies the dust. Twice a week, between the third and first shifts, hand dusting is supplemented by machine dusting. In still another mine, where there is no break between shifts, rock dusting is done at the end of the third shift on Saturdays. If the rate of advance is very rapid, hand dusting is resorted to, and this is then supplemented by machine dusting at the end of the week.

32. The Code requires that the rock dust be maintained within 80 feet of the working faces; however, it is believed that rock dust should be maintained within 2 or 3 cuts of the face. To do this, rock dusting should be a part of the regular cycle of mining. One of two methods can be employed. The machineman or driller can apply dust by hand immediately after completing the cutting or drilling of the face. This has been done successfully in mechanical mining with no additional labor cost and no loss in production of coal. It is believed possible to develop a small, ejector-type duster or to modify one of the small dusting machines now on the market, so that it can be attached to the mining machine or placed on the drill truck. If this scheme is followed, the rock-dust application may be kept up without difficulty, even during normal mining operations and as part of the regular cycle of mining.

HAND DUSTING

33. Hand dusting is slow, labor costs are greater, and frequently distribution of the dust is not as satisfactory as when machines are used for distributing the dust. The dust may be applied by throwing handfuls of dust onto the roof and ribs. If preferred, a sack of rock dust may be placed on the floor, the paper torn, and a shovel used to throw the dust onto the exposed surfaces. Dusting of the floor is not required in most cases, as spillage is sufficient to coat the floor.

34. Care should be taken to apply the dust evenly. If the application is spotty, a larger quantity of dust should be applied at a rate of about 8 pounds per linear foot in entries and twice this amount in wide rooms.

ROCK-DUST SAMPLES

35. It is important to maintain rock dusting adequately, for if the amount of incombustible matter in the mine dust is too low, an explosion may be propagated. Moreover, if less than 65 percent incombustible matter is present and a layer of coal dust has settled on the rock dust, there may not be enough incombustible matter present to prevent propagation of an explosion. To determine the condition of the dust, samples should be taken at regular periods, preferably at intervals not exceeding 2 months. All the dust from the roof and ribs should be brushed into a container making a channel about 6 inches wide. This sample should then be placed in a can or other container and taken to the surface for analysis. The same width of sample should be taken across the roadway at the same point. Whenever the samples contain less than 65 percent incombustible matter, that part of the mine should be redusted promptly.

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COST OF ROCK DUSTING

36. The cost of rock dusting varies according to the type of machine, the type of application, the delivery price of rock dust, the thickness of the coal bed, and other factors. Machine dusting, on an average, costs 0.75 to 1.0 cent per ton of coal produced. If high-pressure dusting is done to a large extent in trackless entries, the cost will be greater. If little or no high-pressure dusting is done, the cost will be proportionately less. When dust is applied by hand, the cost ranges from 4 to 8 cents per ton of coal, unless this is part of the regular mining operation, in which event the labor cost is absorbed in the general expense.

ROCK DUSTING AND MINE EXPLOSIONS

37. In 1937, D. Harrington published data on 11 coal-mine explosions that were stopped by rock dust. Many other explosions have also been stopped by rock dust. A typical example follows: The firing of the first of 2 excessively heavy mud-capped charges of gelatin dynamite on a fall of sandstone roof in a room raised a cloud of coal dust that was ignited by the second shot. The entries of this mine had been well rock-dusted, and unquestionably this saved many lives and much property damage; 6 men who were nearby were killed, but there is no question that many, if not all, of the other 306 persons who were in the mine owe their lives to the effective method of rock dusting. The explosion had considerable force but died away soon after reaching the rock-dusted entries.

38. The need for rock-dusting back entries and air courses as well as haulage roads was demonstrated in the explosion at a large Pennsylvania mine in 1928. Mining men had visited this mine shortly before the explosion; and the general opinion was that the mine was well rock-dusted, even though only the haulage roads were rock-dusted. When the explosion started, it was propagated by dust in the non-rock-dusted back entries and air courses. In this explosion, 193 men lost their lives. If all entries had been rock-dusted as well as the haulage roads, few persons would have been killed.

39. The necessity for rock-dusting rooms and maintaining dust on entries close to the working faces was shown in the recent Centralia mine explosion in which 111 persons lost their lives. The explosion traveled through the non-dusted rooms and the entries beyond the rock-dust application. If the rock dust had been maintained within 80 feet or less of the faces, probably only a few lives would have been lost.

ALLAYING DUST WITH WATER

40. In dry, dusty mines or sections of mines, water should be used to allay the dust. Unless water is applied effectively, dust is thrown into suspension and carried by the ventilating current into air courses. Coal dust settling on the rock dust reduces the effectiveness of the latter, often in places difficult to reach if additional rock dusting is required.

41. Water should be applied on the ribs, roof, and floor of a working place between the face and end of the rock-dust application before the coal is blasted. The coal pile and the face should also be wet after blasting.

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42. During cutting, water should be applied on the cutter bar of mining machines to allay the dust at its source. Details of how to equip mining machines and other mining equipment to control dust with water are given in Bureau of Mines Information Circular 3843, Suggested Methods for Installing Dust-Allaying Equipment in Bituminous-Coal Mines.

43. Dust should be allayed during loading. Sprays may be mounted on mobile loading machines, or the coal pile may be wetted before and during loading, as conditions warrant.

44. If coal loaded in cars is dry, the tops of loaded cars should be watered before they leave the gathering sidetrack. If dust is raised during dumping underground or on the surface and during the handling of coal in the tipple, the addition of a penetrating type of wetting agent to the water used to wet the tops of loaded cars probably will allay dust during these operations.

45. Water for allaying dust underground may be piped from the surface, using town water, mine water (pumped to a reservoir), or water from a stream.

46. Water may be piped to the working faces, or tanks may be filled with water at the surface, at the shaft bottom, or from pipes in the individual working sections of the mine.

47. Where water is scarce, or added moisture in the coal is a problem, a wetting agent may be used with the water. More effective allaying of the dust is obtained, and the volume of water needed is usually less than half that required when no wetting agent is used.

48. The cost of installing a pipe system and of using water for allaying dust ranges from 1-1/2 to 2 cents a ton of coal produced. If a wetting agent is used the added cost is about 0.5 to 0.75 cent per ton.

SOURCES OF ROCK DUST

49. A number of companies sell suitable rock dust. A partial list is given in the Appendix.

CONCLUSIONS

Widespread coal-mine explosions may be prevented if rock dust of suitable size and composition is applied effectively. For maximum protection, the rock dust should be maintained within two or three cuts of the faces. The area between the face and the end of the rock-dust application - which should never exceed 80 feet - should be wetted before blasting. Water should be used on the cutter bar of mining machines, and the coal pile should be wetted after blasting and should be kept wetted during loading, either by application of water from a hose or from spray nozzles on mobile-loading machines. The amount of water required to allay dust may be reduced about half by adding a wetting agent to it.

A widespread explosion is liable to occur in any bituminous-coal mine that is not rock-dusted adequately. It is extremely important, therefore, to maintain rock dusting in the same manner as other mining operations. It is inconceivable why any mining company should hesitate to apply rock dust and to

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maintain it adequately when the cost is only about 1 cent a ton of coal produced. If the precautions given in this circular are taken, coal-dust explosions may be prevented or limited to a very small area.

APPENDIX I

A large number of producers of crushed stone products supply rock dust to coal mines. The names and addresses of some of these producers follow:

Dolcito Quarry, Tarrant, Ala.
Tennessee Coal Iron & Railroad Co., Birmingham, Ala.
National Cement Co., 430 Martin Bldg., Birmingham, Ala.
Black White Lime Co., Front & 8th St., Quincy, Ill.
Columbia Quarry Co., 1612 Syndicate Trust Bldg., St. Louis, Mo.
Consumers Co. of Illinois, 228 N. LaSalle St., Chicago, Ill.
Michigan Limestone & Chemical Co., Rogers City, Mich.
Independent Gravel Co., 220-1/2 W. 4th St., Joplin, Mo.
Herzog Lime & Stone Co., Forest, Ohio
Kelley Island Lime & Transport Co., 1122 Leader Bldg., Cleveland 14, Ohio
Ohio Hydrate & Supply Co., Woodville, Ohio
Bellefonte Stone Products Corp., 50 Broadway, New York, N. Y. (Dist. A)
Millard, H. E., Annville, Pa.
New Castle Lime & Stone Co., 512 Temple Bldg., New Castle, Pa.
New Enterprise Stone & Lime Co., New Enterprise, Pa.
Pittsburgh Limestone Corp., 437 Grant St., Pittsburgh, Pa.
Thomasville Stone & Lime Co., Thomasville, Pa.
Tyrone Lime & Stone Co., 300 First National Bank Bldg., Tyrone, Pa.
Warner Co., 219 N. Broad St., Philadelphia, Pa.
Whiterock Quarries, Bellefonte, Pa.
Utah Lime & Stone Co., 203 Continental Bank Bldg., Salt Lake City, Utah.
James River Hydrate & Supply Co., Buchanan, Va.
Liberty Limestone Corp., Buchanan, Va.
National Gypsum Co., Buffalo, N. Y.
Pembroke Limestone Corp., Box 2459, Roanoke, Va.
Pounding Mill Quarry Corp., Box 2459, Roanoke, Va.
Spokane Portland Cement Co., 724 Old Nat'l Bank Bldg., Spokane, Wash.
Acme Limestone Co., Fort Spring, W. Va.
Greer Limestone Company, Greer, W. Va.

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APPENDIX II

The following Bureau of Mines publications may be consulted to obtain more detailed information on rock dusting and allaying dust.

RI 3034 Effectiveness of Different-Size Rock Dusts in Preventing Coal-Dust Explosions in Mines, by G. S. Rice, H. P. Greenwald, and H. C. Howarth. 1930. 10 pp., 1 fig. Reviews past investigations in Experimental mine and reviews recent series of tests with rock dust of various sizes. Discusses present status of rock-dusting.

RI 3132 Experiments to Determine the Minimum Amount of Coal Dust Required for Propagation of a Mine Explosion, by G. S. Rice and H. P. Greenwald. 1931. 3 pp. Reviews experiments leading to the conclusion that no coal mine can be clean enough to be free of the hazard of dust explosions if a source of ignition is introduced.

RI 3465 Methods of Rock-Dusting American Coal Mines, by J. J. Forbes. 1939. 22 pp. Gives pertinent facts concerning rock-dusting practices in the United States.

RI 3631 Methods of Allaying Dust in Underground Mining Operations, by C. Watson Owings. 1942. 38 pp. Discusses results of a study of methods for allaying dust in coal and metal mines and indicates possible means of reducing concentrations of dust in such mines.

RI 3843 Suggested Methods for Installing Dust-Allaying Equipment in Bituminous-Coal Mines, by C. W. Owings. 1945. 31 pp. Discusses equipment to be used in allaying dust and the method of attaching this equipment to mining equipment.

IC 6030 Rock Dusting in Coal Mines, by G. S. Rice, R. R. Sayers, and D. Harrington. 1927. 3 pp. Gives report of sectional committee of American Engineering Standards Committee embodying recommended practice for rock-dusting coal mines to prevent coal-dust explosions.

IC 6087 Rock-Dusting by Hand Method, by D. Harrington and C. W. Owings. 1928. 7 pp. Points out the procedure necessary to rock-dust adequately exposed surfaces of all accessible places in bituminous and lignitic coal mines.

IC 6129 Sampling Dust in Rock-Dusted Mines, by C. W. Owings. 1929. 8 pp. Discusses methods of sampling dusts to determine percentage of incombustible material as a guide to adequate rock-dusting.

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IC 6578 **Good Rock-Dusting and Ventilation Practice in Two Alabama Coal Mines, by F. E. Cash. 1932. 12 pp., 6 figs. Shows how adequate ventilation, thorough rock-dusting, and use of water on cutter bars and cars can reduce explosion hazards in bituminous-coal mines.**

IC 7113 **Methods of Sampling and Analyzing Coal-Mine Dusts for Incombustible Content, by C. W. Owings, W. A. Selvig, and H. P. Greenwald. 1940. 12 pp., 5 figs. Prepared in conjuction with I. C. 7109, Mine Safety Board Decision 32, to describe, as concisely and simply as possible, steps that must be taken to determine incombustible content of coal-mine dusts, with enough accuracy to permit their control.**

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